EXPRESS Pallet Payload and Optical Window Accommodations for the International Space Station

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OSS & OES Research Program Office, GSFC

ESSP-3 AO Pre-Proposal Conference

6/14/01

Agenda

RPO Role

ISS Vehicle

EXPRESS Pallet

Considerations on Unpressurized ISS Use

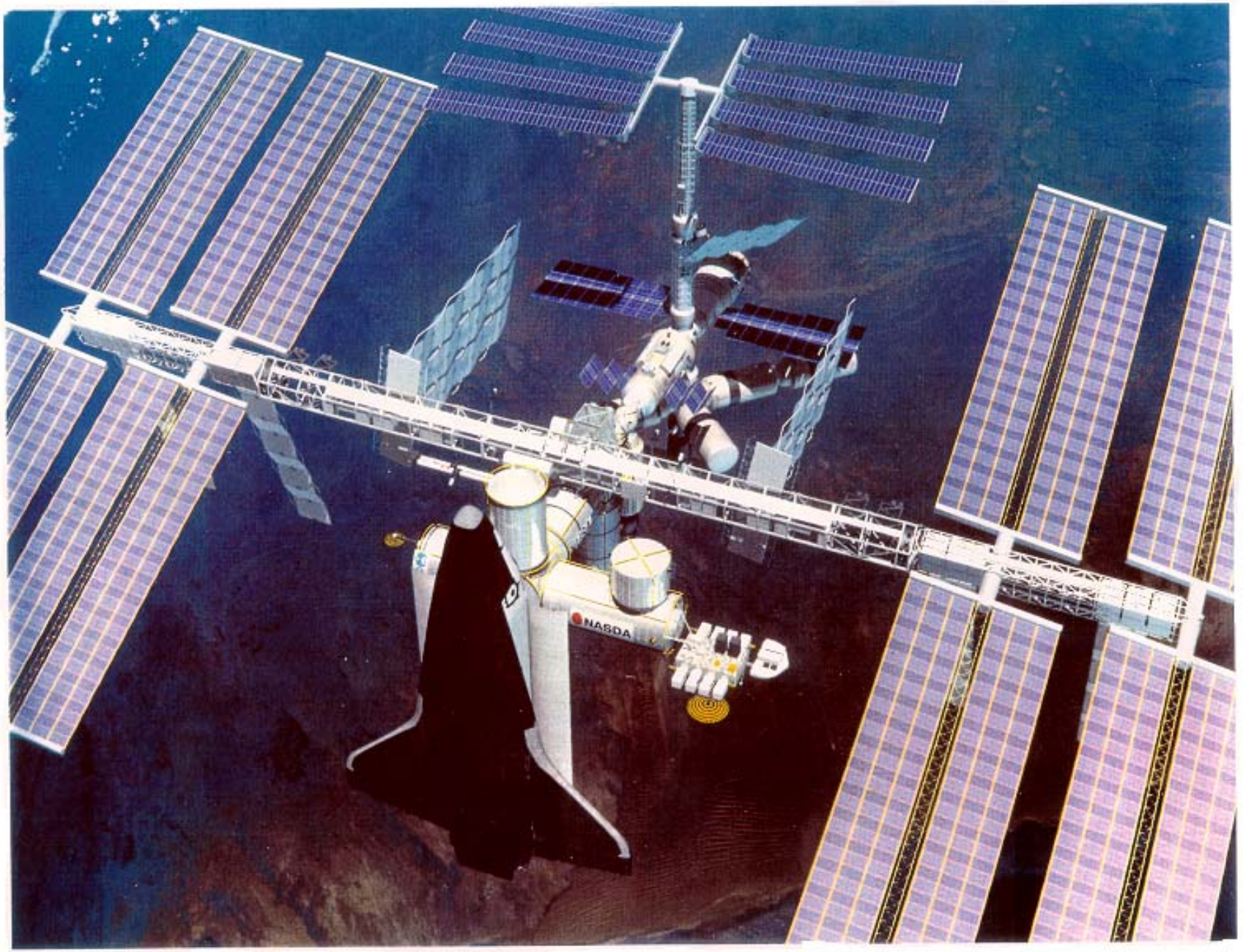
WORF

Considerations on Pressurized ISS Use at the WORF

General ISS Payload Consideration:

- Manned Flight Safety
- Crew Training
- Operation Concept
- Retrieval
- STS and ISS Reviews

RPO Website


NASDA

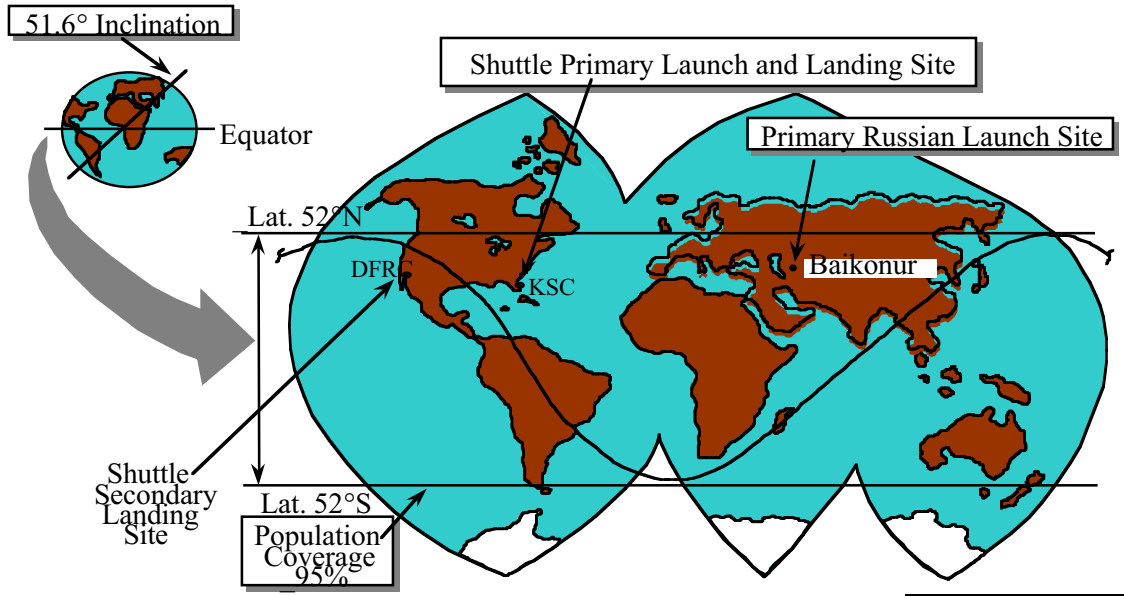
RPO Role for Payload Support

- Coordinate payload planning, accommodations, allocations, manifesting, development, integration, and operations, and any associated issues between HQ, payload developers, international partners, other NASA centers, and the ISS Program
- Assist ISS Program/Boeing in defining payload interface requirements including thermal, mechanical, electrical, data, contamination, operations, crew training, programmatic (schedules, data deliverables, documentation, reviews)
- Shepherd payload developers through the STS/ISS systems, procedures, and reviews

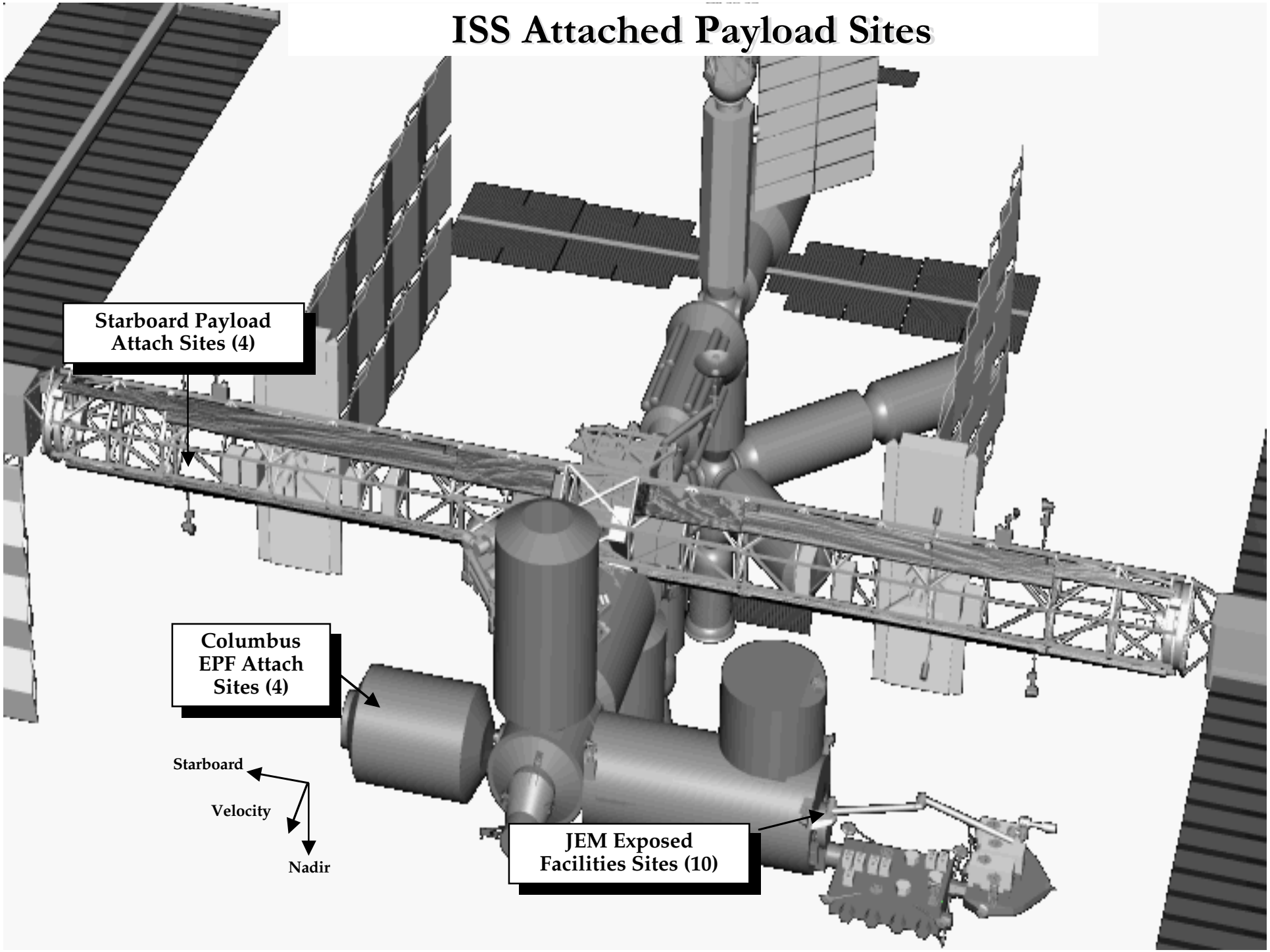
ISS Vehicle

Orbit

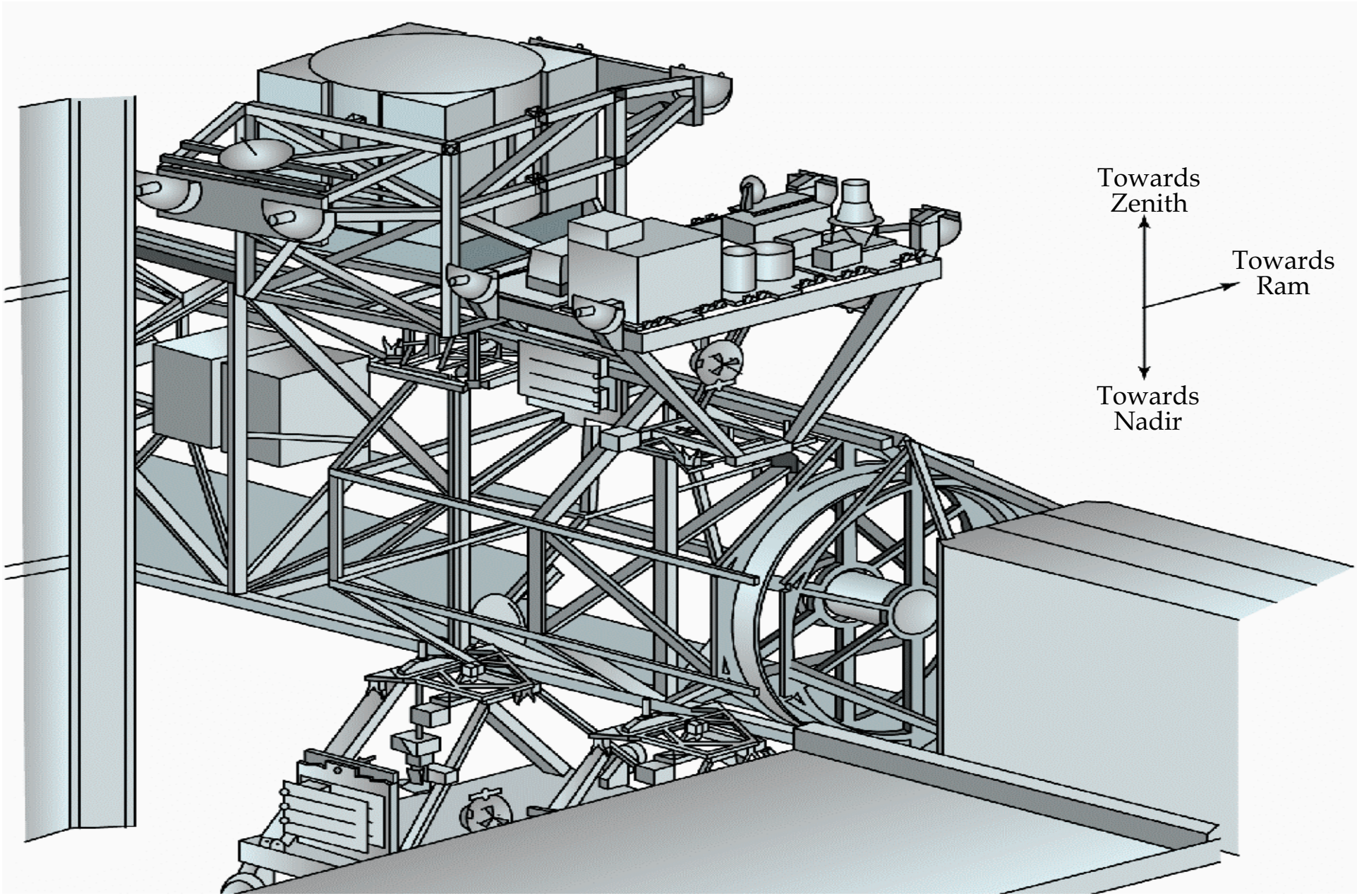
- Nearly circular, inclination 51.6 deg
- Altitude 189 to 248 nautical miles (350 - 460 Km)
- Reaches maximum 52° latitude north and south
  - Covers 85% of globe, 95% Earth's population
- Flies over same spot approximately every 3 days, with the same lighting every 3 months



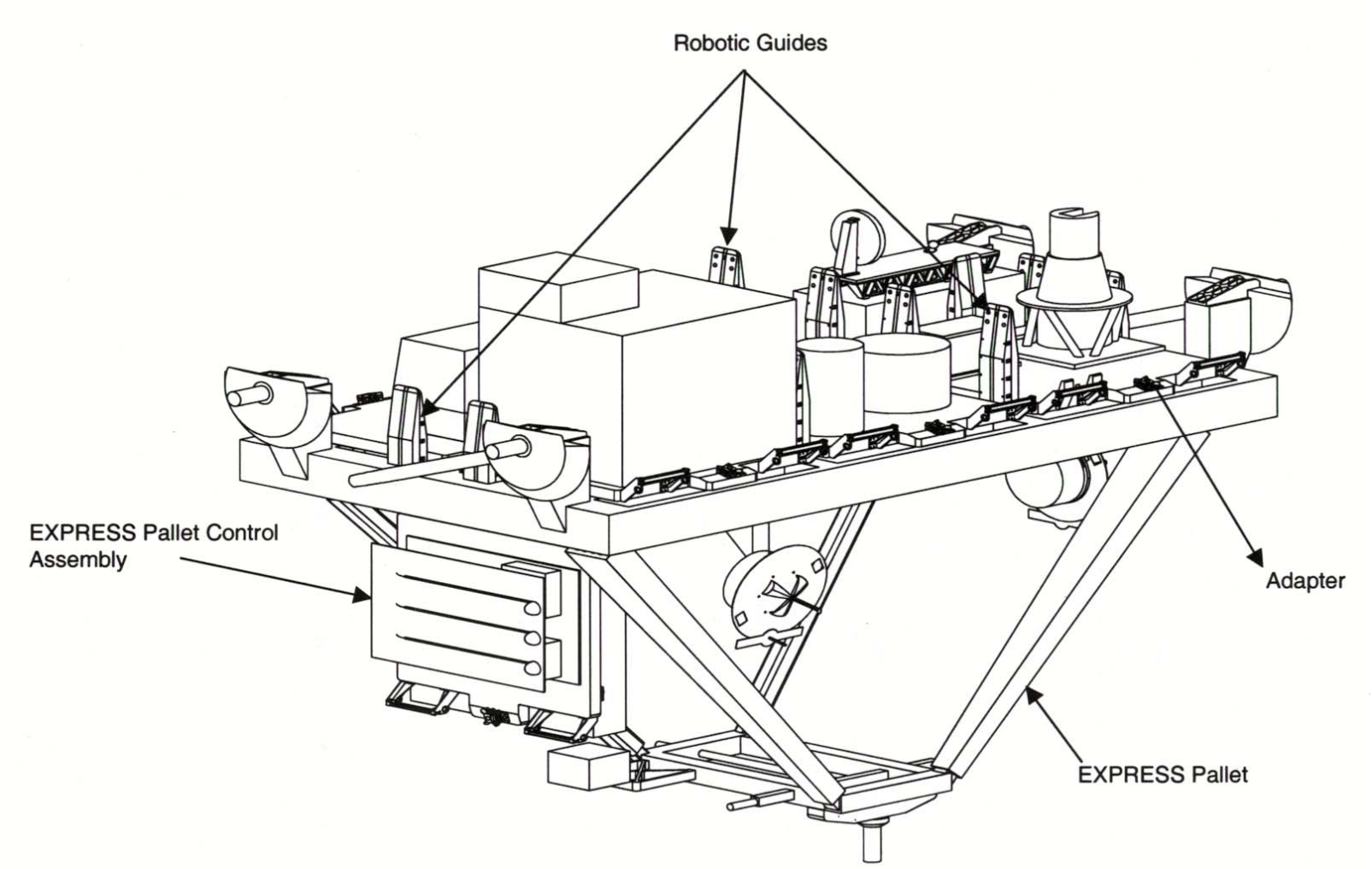
ISS Attached Payload Sites



U.S. Truss



EXPRESS Pallet



U.S. Truss - EXPRESS Pallet

- 2 nadir pallets and 1 zenith pallet on starboard truss currently planned
- 6 adapter plates per pallet
- All sites are allocated to NASA
  - Exceptions for the Canadian Space Agency (CSA) and barter arrangements with International Partners
- Mass 227 Kg per adapter payload
- Payload Envelope
  - 1.1m ram/wake
  - 0.86m inboard/outboard
  - 1.2m zenith/nadir
- Power
  - 750 W of 120 Vdc and 500 W of 28 Vdc available per site, however power will be limited by ability to dissipate heat
  - 2.5 kW of combined 120 Vdc and 28 Vdc to be shared by 6 adapter payloads
  - 120 Vdc keep-alive power during ISS reduced power modes and 120 Vdc contingency power provided

U.S. Truss - EXPRESS Pallet (Con't)

- Data
  - Low rate telemetry via MIL-STD-1553B bus, max 20Kbps available to Pallet, assume 2 Kbps per adapter payload
  - 6 analog signals and 6 bi-level discretes available per adapter payload monitored by Pallet Controller Assembly
  - High rate science data provided via Pallet ethernet, assume
    - 6 Mbps max throughput for Pallet
    - 250 Kbps average data generation rate per payload
    - Payloads buffer data
    - Transmit at 1Mbps average rate or 6Mbps burst

U.S. Truss - EXPRESS Pallet (Con't)

- Pointing
  - Knowledge 0.1 deg at GPS sites
    - Degrades with distance to ~1-2 deg at S3 attach sites
  - Stability 2.5 deg/axis/orbit
    - Pointers are being developed outside of NASA for specific EXPRESS Pallet adapter payloads
    - Payloads must provide own pointers
- No thermal control provided by Pallet
- Pallet/Payload mechanical interface hardware and use of shipping container provided by ISS Program
- Robotic installation and retrieval primary, Extravehicular Activity (EVA) contingency only
- Carrier
  - First payload set launches on Pallets
  - Returning payloads and future individual payloads ride on carriers provided by ISS Program

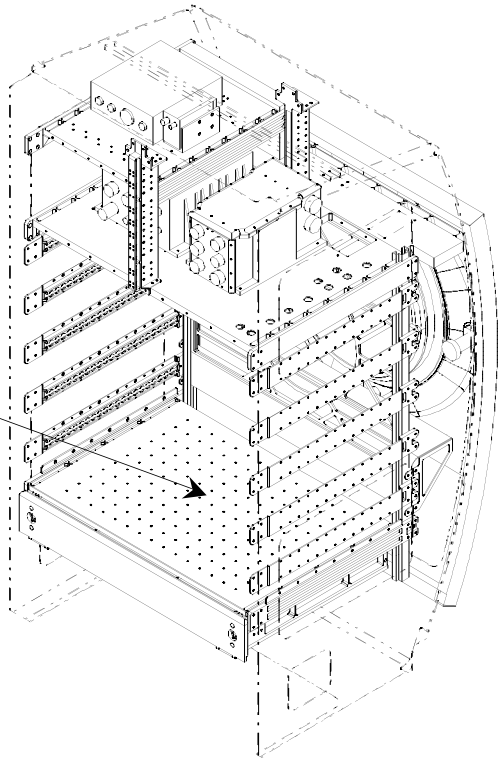
Considerations on Unpressurized ISS Use

- Contamination
  - Molecular Deposition of the ISS Environment = 130 A/yr
  - Need to be concerned about molecular deposition (long-term and sporadic). Issue is especially critical for short wavelength instruments
    - Use of retractable aperture covers can help (e.g., SAGE III)
- Altitude
  - Can vary from 190 to 250 nmi with smaller short-term variations superimposed on longer solar-cycle induced variation
  - Altitude reboost anticipated approximately every 3 months (nominally)
- Attitude Knowledge/Pointing
  - ISS attitude knowledge will be reasonable well known and stable, but fine pointing knowledge/control at the location of instrument may need to be augmented by the payload
  - ISS attitude holding capability (2.5 degrees per axis per orbit) may need to be augmented by payload pointing (e.g., HEXAPOD for SAGE III)

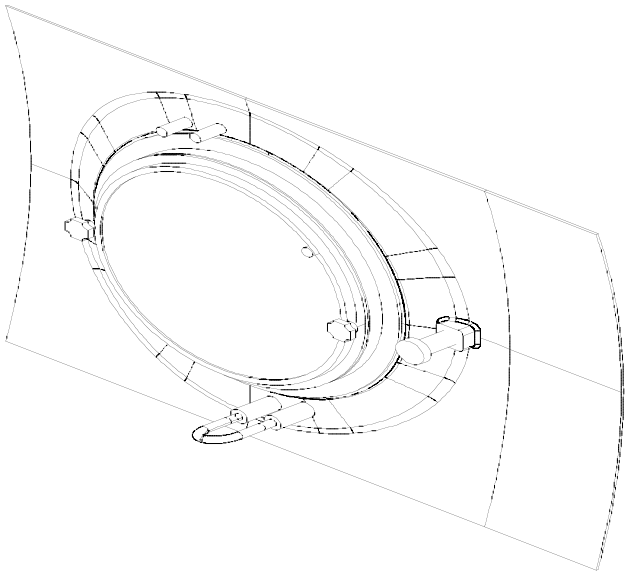
Considerations on ISS Use (Con't)

- Viewing
  - Possibility exists for partial or periodic obstruction of viewing by Shuttle visits, solar panels, other instruments, etc.
- Power
  - Have significant power available but will need to share with other instruments
  - Will be periods of low power, e.g., during shuttle/ELV dock/undock
- Data Handling/Communication
  - Can command via S-band, get downlink via Ku band with good but not complete coverage
  - Payloads need capability to store and dump high rate science data
- Upmass
  - Launch opportunities are scheduled but infrequent until the ISS assembly is complete

Window Observational Research Facility (WORF)

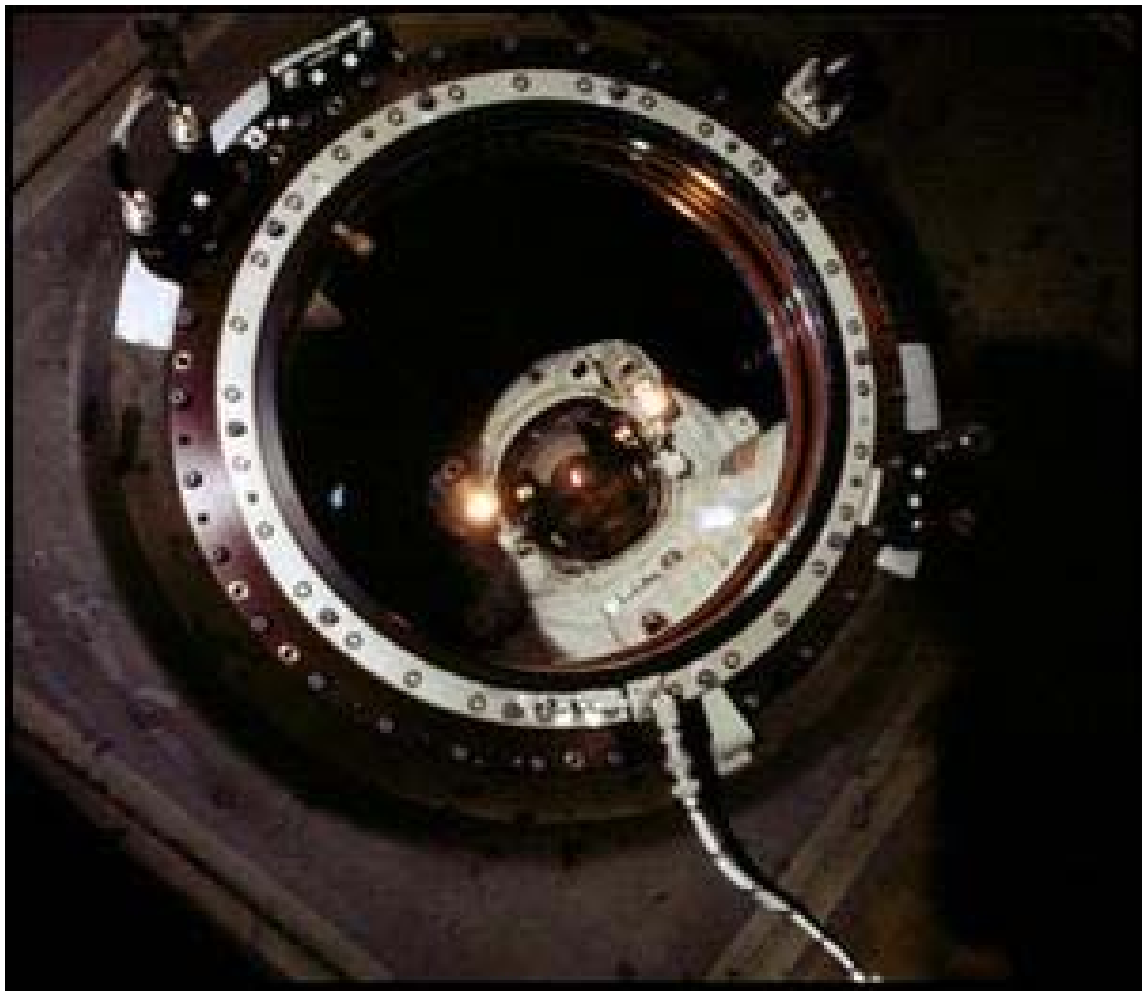


WORF 3/4 schematic view showing the relationship between payload volume and avionics bays.

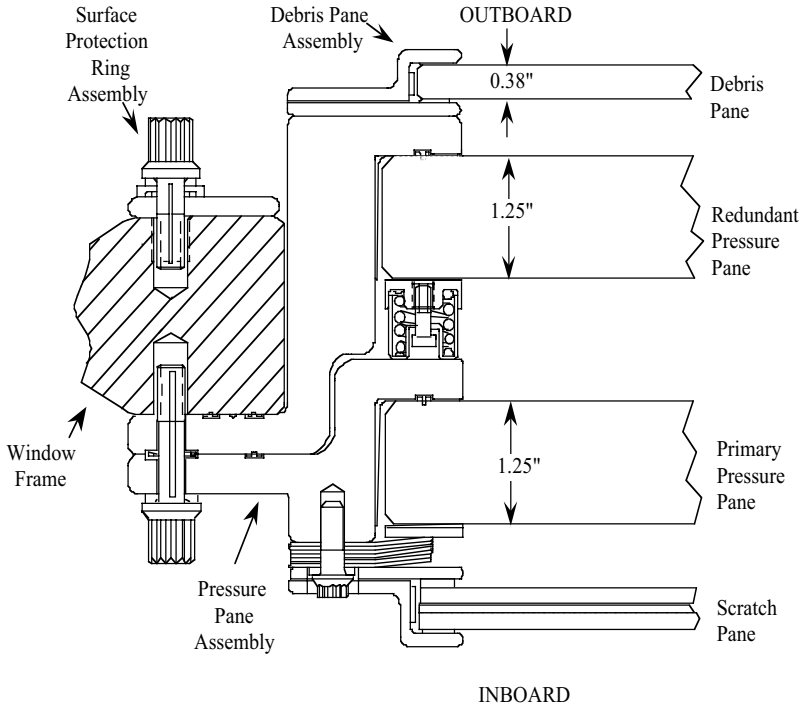


US Laboratory nadir window; the pane (Fused Silica) has a 20” (50.8cm) clear viewing area. To the right of the window is the handwheel for opening the window shutter. The “U”-shaped structure below the window is a quick disconnect (QD) that controls the pressure between the two pressure panes.

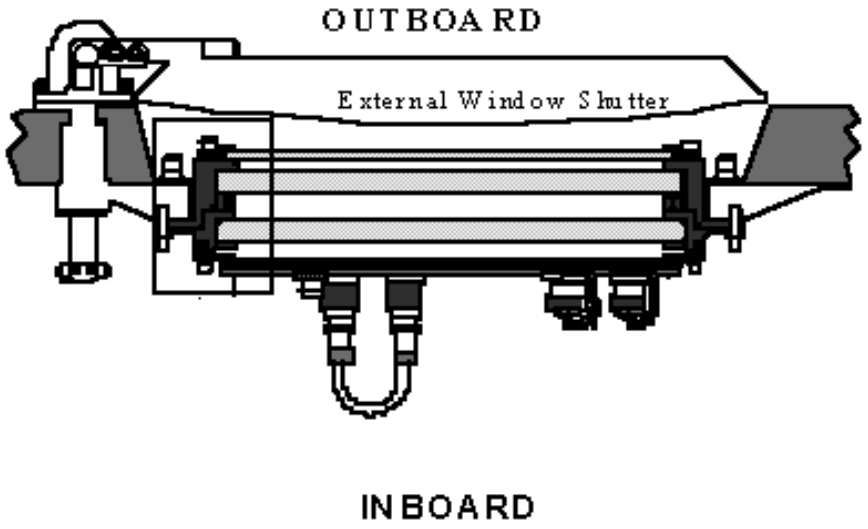
Window on Orbit



ISS WORF



Schematic showing the construction of the nadir window and its Integration into the window mount. The kick pane will be removed for during window research operations.

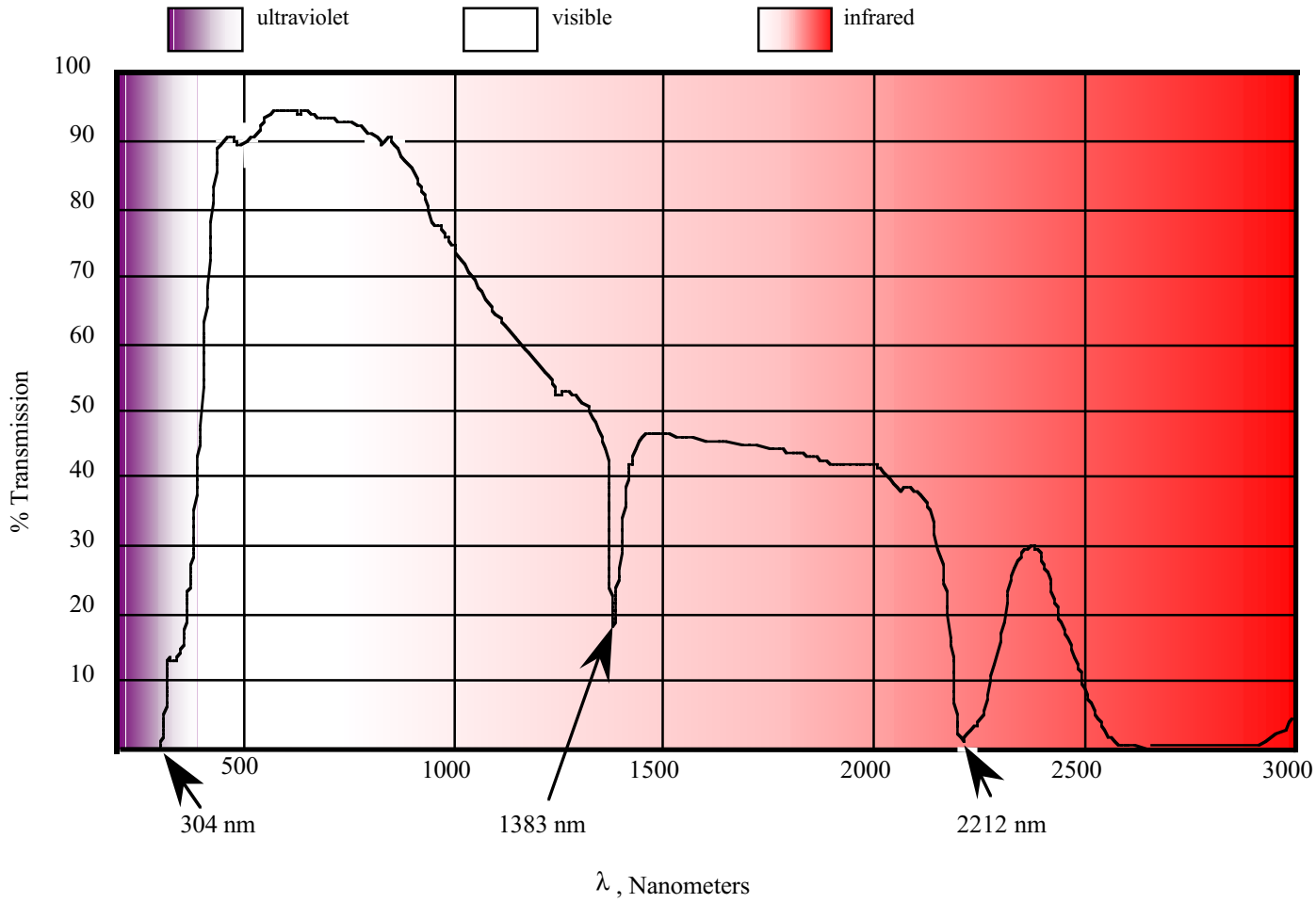


Window/mount integration into the Space Station structure. The external cover can be moved out of the way by use of the hand wheel located to the left.

ISS WORF

- 20-inch diameter fused silica window located in nadir side of the US Laboratory Module
- Optical quality of window is superior to any window flown on a manned mission
  - Measured optical quality confirms wavefront error of λ / 14 over 6-inches, peak to valley, reference λ = 632.8nm, with scratch pane removed for payload operations
- WORF rack adjacent to window provides support infrastructure for camera/remote sensor operations

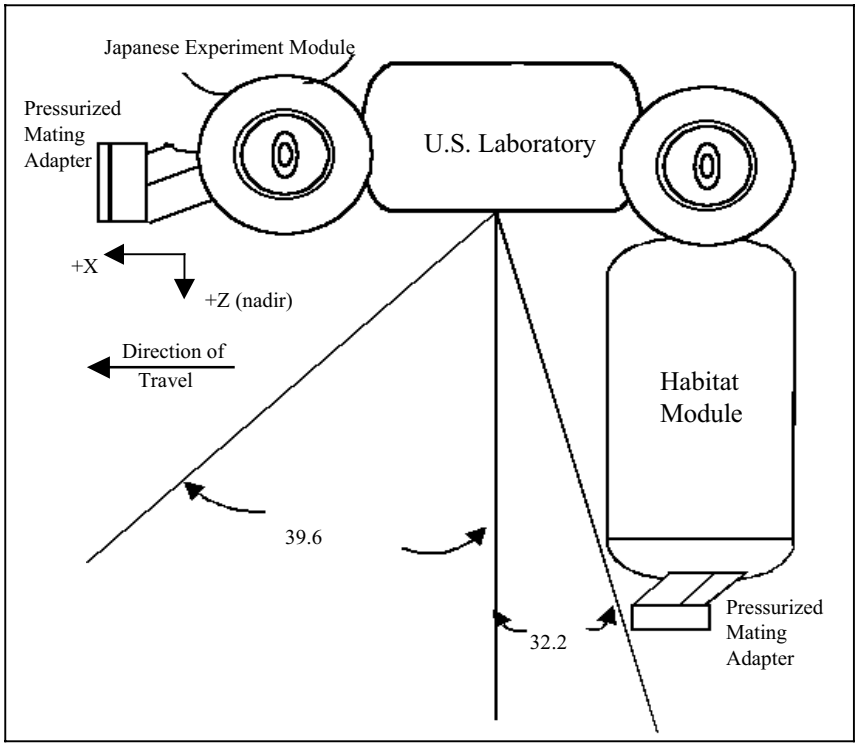
Window Transmittance Curve



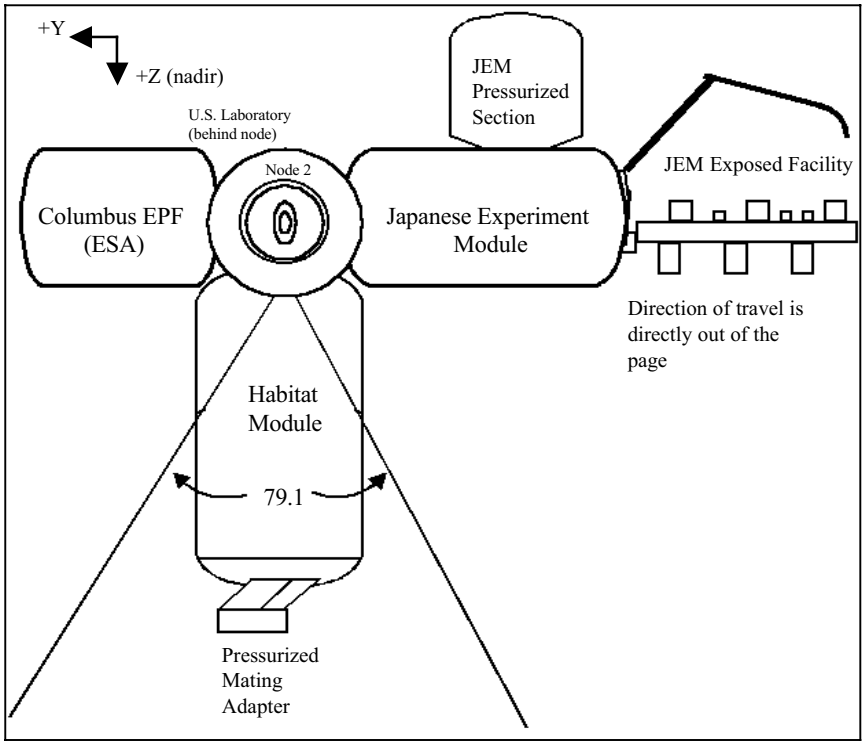
ISS WORF

- Payload Mass
  - 136 Kg
- Payload Envelope
  - 53.3cm x 76.2cm x 50.8cm
- Power
  - 28 Vdc, 560 W maximum to any payload interface
  - 2 kW total available for payloads
    - Thermal system capacity determines allowable power draw
- Data
  - Maximum data rate 8 Mbps with approximately 1.3 Gb storage provided
  - Low and medium rate telemetry and video available
  - 2 analogs and 3 discretes per payload
- 2 Primary means of thermal control
  - Forced air cooling
  - Water cooling
- Payloads can be operated in any combination of crew operated, crew tended, ground commanded, or fully autonomous

WORF Field-Of-View Schematic



Schematic of the International Space Station, showing the field of view for the window in the X-Z plane.



Schematic of the International Space Station, showing the fields of view for the window in the Y-Z plan, orthogonal to the view shown in figure 2.

Considerations on Pressurized ISS Use for Earth Science Research

- Altitude
  - Can vary from 190 to 250 nmi with smaller short-term variations superimposed on longer solar-cycle induced variation
- Attitude/Pointing Knowledge
  - Pointing knowledge is available in the ISS data stream but may need to be augmented by payloads
- Vibration Isolation
  - Window facility designed to mitigate vibration input from ISS environment, payloads with large optics may need augmentation for vibration isolation
- Crew Interaction
  - Payload may be completely autonomous or have varying levels of crew interactions/operations

Considerations on Pressurized ISS Use for Earth Science Research (Con't)

- Viewing
  - Viewing limited to Window Field-Of-View but with no obstructions
- Power/Thermal
  - Substantial power available with active thermal control
- Data Handling/Communication
  - Can command via S-band, get downlink via Ku band with good but not complete coverage
- Transport to ISS via various possible carriers:
  - Multi-Payload Logistics Module (MPLM)
  - Middeck Locker(s)
  - SPACEHAB Locker

General ISS Payload Considerations: Manned Flight Safety

- STS and ISS safety review system combined for flight and ground
- Substantial documentation increase over ELVs
- Significant safety oversight required
  - Safety and hazard verification
- Level of rigor independent of payload size or $ value
  - 3 step review process
  - Phase 1 review within 3 months of PDR

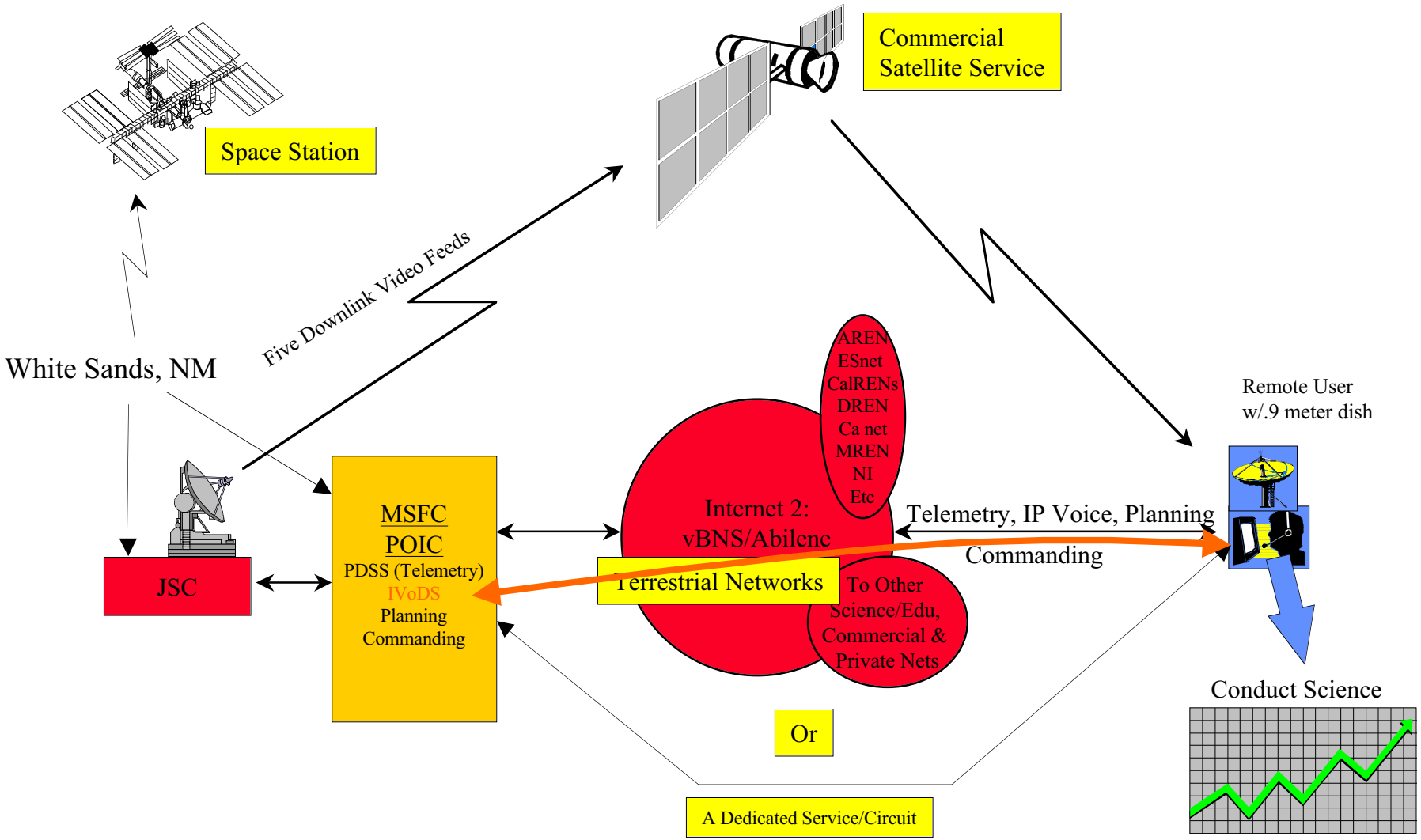
General ISS Payload Considerations: Crew Training

- "Standard" operations don't require Payload Developer (PD) input, e.g. robotic placement
- Unique payload handling on-orbit requires training procedures, documentation
- Crew familiarization package to be provided by PD
- Contingency operations involving crew intervention will require ground or on-board training

General ISS Payload Considerations: Ops Concept

- PI operates payload and receives data through MSFC via a workstation at a secure location of PI's choice
- Increment = crew rotation period, ~ 3 months
- Planning Period ~ 1 year
- "Increment Scientist" (IS) represents all Code Y payloads operating on ISS for a planning period and works directly with PIs
- IS is part of a team with a Lead Increment Scientist who represents all payloads to ISS Program during ops and contingencies
- Reporting required after each increment with additional post flight reporting

ISS TO SCIENCE USER END TO END CONNECTIVITY



General ISS Payload Considerations: Retrieval

- Payloads must be returned to ground
- Retrieval planning must take place prior to launch
- Payload anomalies and configuration changes must be tracked while on-orbit
- Safety re-assessment requires original design documents and operations records be maintained
- Retrieval Certification of Flight Readiness (CoFR) and Safety review required
- De-integrate from STS and return payload to PI
- MO & DA budget must include reserved retrieval costs

Payload Supported STS/ISS Reviews and Deliverables

The payload developer must support a certain template of ISS Program reviews and deliverable. The following is a minimum, but not limited to, list of those items:

Reviews (Payload Must Attend)	**Approx. Date**
Flight/Ground Payload Safety Review – Phase 0/1	PDR +3 mos
Flight/Ground Payload Safety Review – Phase 2	L-20 mos
Payload Increment Requirements Review (PIRR)	L-12, L-8, L-4 mos
Flight/Ground Payload Safety Review – Phase 3	L-9 mos
GSFC RPO Payload System Acceptance Review = Preship	L-6.5 mos
Rollout Status and Launch/Mission Readiness Review	L-12 wks
Certification of Flight Readiness (CoFR) Review	L-6 wks

Reviews (Payload May Need to Provide Inputs)	**Approx. Date**
Cargo Integration Review (CIR) – (Full Truss Payload)	L-9 mos
Increment Operations Readiness Review (IORR)	L-9 mos
Increment Flight Operations Review (IFOR)	L-7 mos
Flight Operations Review (FOR)	L- 4 mos
Flight Readiness Review (FRR)	L-2 wks

Payload Supported STS/ISS Reviews and Deliverables (Con't)

Deliverable	Approx. Date
Flight/Ground Payload Safety Data Packages Phase 0/1	PDR +1 mos
Flight/Ground Payload Safety Data Packages – Phase 2	L-22 mos
Flight/Ground Payload Safety Data Packages – Phase 3	L-11 mos
Payload Integration Agreement (PIA) and Unique Addenda	Refer to Site Specific Documentation
Mission Evaluation Request (MER)	Refer to Site Specific Documentation
Baseline Payload Verification Plan	Refer to Site Specific Documentation
Completed Payload Verification Requirement Sheets	Refer to Site Specific Documentation
Draft System Requirements Data Set (SRDS)	Refer to Site Specific Documentation
Baseline SRDS	Refer to Site Specific Documentation
Ship Payload to KSC	L-6 mos (Nominal)
Payload Turnover to KSC	L-4.5 mos (Nominal)

Contact Us

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